California Environmental Protection Agency

Air Resources Board

PERMEATION RATES OF
SMALL OFF ROAD ENGINE
HIGH - DENSITY POLYETHYLENE
FUEL TANKS
(APRIL 2001 TESTING)

Engineering and Certification Branch
Monitoring and Laboratory Division

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Introduction

The California Air Resources Board (CARB) staff tested twelve High-Density Polyethylene (HDPE) fuel tanks to determine their permeation rates. Tanks were preconditioned with commercial fuel, refilled with Phase II California Reformulated Certification (CERT) fuel, and subjected to a variable temperature profile. Permeation rates were then determined gravimetrically during the month of April.

Test Protocol

In February and March the untreated tanks used with 4-cycle engines underwent the preconditioning process using commercial fuel, per CARB Test Method 513. Untreated tanks used with 2-cycle engines underwent the preconditioning process using a 2% commercial fuel/oil mixture. The tanks were stored at ambient temperature and pressure in flameproof storage cabinets. After at least four weeks of ambient preconditioning, the tanks were emptied; dried with compressed zero air, and immediately refilled with either CERT fuel or a 2% CERT fuel mixture. The tanks were then sealed using a hand held fusion welder and 1/4" thick HDPE coupons and leak tested as specified in Test Method 513 (a copy can be found at the CARB web site: http://www.arb.ca.gov/regact/spillcon/spillcon.htm).

Weight loss was used to determine relative permeation rates. Sealed tanks were weighed using a 16,000 gram or 6,200 gram balances with sensitivities of ±0.1 and ± 0.01 grams respectively**.** After each tank was weighed, the weight was recorded. They were then placed in the Sealed Housing for Evaporative Determination (SHED) and exposed to a 1-day/24-hour/1440-minute variable temperature profile (see Attachment 1). This profile is considered our diurnal cycle (recurring every day). Tanks were then post weighed after each 24-hour diurnal cycle and the weight loss calculated.

Results

Cumulative weight losses were determined for each container as a function of time. The tanks underwent multiple diurnal cycles, but results are calculated using only the last five 24 hour cycles. The initial days of test data were not used in determining individual per container permeation rates due to high variability. A summary of all test results can be found in Attachment 2.

The average permeation rate from the 3.9 gallon Toro tank (72045) designated T6 was determined to be 0.77grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 7.5 gallon Toro tank (3100) designated T8 was determined to be 0.35 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.16 gallon 2-cycle Echo leaf blower tank (PB-231) designated T15 was determined to be 1.88 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.25 gallon Briggs & Stratton tank (695106) designated T24A was determined to be 5.56 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.25 gallon Briggs & Stratton tank (695106) designated T24B was determined to be 5.17 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.15 gallon 2-cycle Echo string trimmer tank (SRM-261) designated T26 was determined to be 3.09 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 1.75 gallon Toro tank (71197) designated T28 was determined to be 1.05 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 2-cycle Frigidare Home Products tank (530-049393) designated T33 was determined to be 2.74 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 2-cycle Frigidare Home Products tank (530-038592) designated T34 was determined to be 2.94 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 2-cycle Frigidare Home Products tank (530-049318) designated T35 was determined to be 2.08 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 2-cycle Frigidare Home Products tank (530-052343) designated T36 was determined to be 3.00 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.25 gallon Tecumseh tank (11A-021C000) designated T40 was determined to be 2.74 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.25 gallon Briggs & Stratton tank (12A-559K401) designated T41 was determined to be 4.08 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.38 gallon 2-cycle Stihl leaf blower tank (BR-340) designated T45 was determine1d to be 0.21 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

Attachment 1

1 Day / 24 Hour / 1440 Minute Variable Temperature Profile

HOUR	MINUTE	TIME REMAINING (MINUTES)	TEMPERATURE (°F)
0	0	1440	65.0
1	60	1380	66.6
2	120	1320	72.6
3	180	1260	80.3
4	240	1200	86.1
5	300	1140	90.6
6	360	1080	94.6
7	420	1020	98.1
8	480	960	101.2
9	540	900	103.4
10	600	840	104.9
11	660	780	105.0
12	720	720	104.2
13	780	660	101.1
14	840	600	95.3
15	900	540	88.8
16	960	480	84.4
17	1020	420	80.8
18	1080	360	77.8
19	1140	300	75.3
20	1200	240	72.0
21	1260	180	70.0
22	1320	120	68.2
23	1380	60	66.5
24	1440	0	65.0

Attachment 2

PERMEATION TEST RESULTS

April 2001

Diurnal Cycles (# 24 hr cycles)	Tank Label	Mfg.	Tank Volume	Treatment Level	Test Dates	Fuel Type	Avg. Loss (g/gal/day)
5	T6	Toro	3.9 gal	Untreated	3/30 - 4/11	CERT	0.77
5	T8	Toro	7.5 gal	Untreated	3/30 - 4/11	CERT	0.35
5	T15	Echo	0.16 gal	Untreated	3/30 - 4/11	CERT Mix	1.88
5	T24A	Briggs	0.25 gal	Untreated	3/30 - 4/11	CERT	5.56
5	T24B	Briggs	0.25 gal	Untreated	3/30 - 4/11	CERT	5.17
5	T26	Echo	0.15 gal	Untreated	3/30 - 4/11	CERT Mix	3.09
5	T33	FHP		Untreated	3/30 - 4/11	CERT Mix	2.74
5	T34	FHP		Untreated	3/30 - 4/11	CERT Mix	2.94
5	T35	FHP		Untreated	3/30 - 4/11	CERT Mix	2.08
5	T36	FHP		Untreated	3/30 - 4/11	CERT Mix	3.00
5	T40	Tecumseh	0.25 gal	Untreated	3/30 - 4/11	CERT	2.74
5	T41	Briggs	0.25 gal	Untreated	3/30 - 4/11	CERT	4.08
5	T45	Stihl	0.38 gal	Untreated	3/30 - 4/11	CERT Mix	0.21
						Average	**2.66**

Attachment 2

Label	T6				
Tare	1705		Fuel Density		2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	11093.8	11091.9	1.9	0.56
D2	11091.9	11089.7	2.2	0.65
D3	11089.7	11087.8	1.9	0.57
D4	11087.8	11085.6	2.2	0.65
D5	11085.6	11083.0	2.6	0.77
D6	11083.0	11080.7	2.3	0.68
D7	11080.7	11078.0	2.7	0.80
D8	11078.0	11075.4	2.6	0.77
D9	11075.4	11072.7	2.7	0.80
			Avg.	0.77

Label	T8				
Tare	3886.4		Fuel Density		2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	15963.1	15962.6	0.5	0.12
D2	15962.6	15961.5	1.1	0.25
D3	15961.5	15961.7	-0.2	-0.05
D4	15961.7	15960.5	1.2	0.28
D5	15960.5	15958.7	1.8	0.42
D6	15958.7	15957.4	1.3	0.30
D7	15957.4	15956.0	1.4	0.32
D8	15956.0	15954.5	1.5	0.35
D9	15954.5	15952.9	1.6	0.37
			Avg.	0.35

A**ttachment 2 Continued**

Label	T15			
Tare	227.5		Fuel Density	2804 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	653.59	653.37	0.22	1.45
D2	653.37	653.11	0.26	1.71
D3	653.11	652.85	0.26	1.71
D4	652.85	652.62	0.23	1.52
D5	652.62	652.34	0.28	1.85
D6	652.34	652.07	0.27	1.78
D7	652.07	651.78	0.29	1.92
D8	651.78	651.50	0.28	1.85
D9	651.50	651.20	0.30	1.98
			Avg.	1.88

Label	T24A			
Tare	659.20		Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	1323.62	1322.35	1.27	5.33
D2	1322.35	1321.07	1.28	5.39
D3	1321.07	1319.84	1.23	5.19
D4	1319.84	1318.54	1.30	5.49
D5	1318.54	1317.24	1.30	5.50
D6	1317.24	1315.93	1.31	5.56
D7	1315.93	1314.62	1.31	5.57
D8	1314.62	1313.31	1.31	5.58
D9	1313.31	1312.00	1.31	5.59
			Avg.	5.56

A**ttachment 2 Continued**

Label	T24B				
Tare	660.85		Fuel Density		2791 grams/gallon
Day	Wi grams	Wf grams	Change	Permeation	
D1	1364.64	1363.41	1.23	4.88	
D2	1363.41	1362.12	1.29	5.12	
D3	1362.12	1360.84	1.28	5.09	
D4	1360.84	1359.55	1.29	5.14	
D5	1359.55	1358.27	1.28	5.11	
D6	1358.27	1356.97	1.30	5.20	
D7	1356.97	1355.67	1.30	5.21	
D8	1355.67	1354.38	1.29	5.18	
D9	1354.38	1353.10	1.28	5.15	
			Avg.	5.17	

Label	T26				
Tare	219.59		Fuel Density		2804 grams/gallon
Day	Wi grams	Wf grams	Change	Permeation	
D1	557.15	556.78	0.37	3.07	
D2	556.78	556.43	0.35	2.91	
D3	556.43	556.08	0.35	2.91	
D4	556.08	555.74	0.34	2.83	
D5	555.74	555.37	0.37	3.09	
D6	555.37	555.00	0.37	3.09	
D7	555.00	554.63	0.37	3.09	
D8	554.63	554.25	0.38	3.18	
D9	554.25	553.89	0.36	3.02	
			Avg.	3.09	

A**ttachment 2 Continued**

Label	T33			
Tare	211.14		Fuel Density	2804 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	503.05	502.81	0.24	2.31
D2	502.81	502.57	0.24	2.31
D3	502.57	502.32	0.25	2.41
D4	502.32	502.06	0.26	2.50
D5	502.06	501.77	0.29	2.80
D6	501.77	501.50	0.27	2.60
D7	501.50	501.20	0.30	2.90
D8	501.20	500.94	0.26	2.51
D9	500.94	500.64	0.30	2.90
			Avg.	2.74

Label	T34			
Tare	168.19		Fuel Density	2804 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	406.11	405.90	0.21	2.47
D2	405.90	405.69	0.21	2.48
D3	405.69	405.47	0.22	2.60
D4	405.47	405.25	0.22	2.60
D5	405.25	405.01	0.24	2.84
D6	405.01	404.77	0.24	2.84
D7	404.77	404.52	0.25	2.96
D8	404.52	404.28	0.24	2.85
D9	404.28	404.01	0.27	3.21
			Avg.	2.94

Attachment 2 Continued

Label	T35			
Tare	218.25		Fuel Density	2804 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	475.79	475.66	0.13	1.42
D2	475.66	475.49	0.17	1.85
D3	475.49	475.31	0.18	1.96
D4	475.31	475.15	0.16	1.75
D5	475.15	474.98	0.17	1.86
D6	474.98	474.79	0.19	2.08
D7	474.79	474.61	0.18	1.97
D8	474.61	474.40	0.21	2.30
D9	474.40	474.20	0.20	2.19
			Avg.	2.08

Label	T36			
Tare	168.63		Fuel Density	2804 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	364.33	364.13	0.20	2.87
D2	364.13	363.95	0.18	2.58
D3	363.95	363.75	0.20	2.87
D4	363.75	363.56	0.19	2.73
D5	363.56	363.35	0.21	3.02
D6	363.35	363.14	0.21	3.02
D7	363.14	362.95	0.19	2.74
D8	362.95	362.74	0.21	3.03
D9	362.74	362.52	0.22	3.18
			Avg.	3.00

Attachment 2 Continued

Label	T40			
Tare	294.91		Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	977.17	976.59	0.58	2.37
D2	976.59	976.00	0.59	2.42
D3	976.00	975.39	0.61	2.50
D4	975.39	974.74	0.65	2.67
D5	974.74	974.06	0.68	2.79
D6	974.06	973.42	0.64	2.63
D7	973.42	972.74	0.68	2.80
D8	972.74	972.09	0.65	2.68
D9	972.09	971.41	0.68	2.80
			Avg.	2.74

Label	T41			
Tare	427.99		Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	1177.01	1176.00	1.01	3.76
D2	1176.00	1174.97	1.03	3.84
D3	1174.97	1173.95	1.02	3.81
D4	1173.95	1172.89	1.06	3.97
D5	1172.89	1171.78	1.11	4.16
D6	1171.78	1170.71	1.07	4.02
D7	1170.71	1169.63	1.08	4.06
D8	1169.63	1168.52	1.11	4.18
D9	1168.52	1167.46	1.06	4.00
			Avg.	4.08

Attachment 2 Continued

Label	T45				
Tare	442.28		Fuel Density		2804 grams/gallon
Day	Wi grams	Wf grams	Change	Permeation	
D1	1140.64	1140.50	0.14	0.56	
D2	1140.50	1140.39	0.11	0.44	
D3	1140.39	1140.31	0.08	0.32	
D4	1140.31	1140.26	0.05	0.20	
D5	1140.26	1140.23	0.03	0.12	
D6	1140.23	1140.16	0.07	0.28	
D7	1140.16	1140.07	0.09	0.36	
D8	1140.07	1140.02	0.05	0.20	
D9	1140.02	1140.00	0.02	0.08	
			Avg.	0.21	